San Joaquin Renewables Class VI Permit Application Testing and Monitoring Plan

Prepared for

San Joaquin Renewables LLC
McFarland, California

Submitted to

U.S. Environmental Protection Agency Region 9
San Francisco, California

Prepared by

DBS&A
Daniel B. Stephens & Associates, Inc.

a Geo-Logic Company

43 Randolph Road, #129
Silver Spring, Maryland 20904
www.dbstephens.com

Project # DB19.1252.SS

October 13, 2021

Table of Contents

List of Figures

List of Appendices

1. Introduction

This Testing and Monitoring Plan is a component of the San Joaquin Renewables, LLC (SJR) application to the U.S. Environmental Protection Agency Region 9 (U.S. EPA) for an Underground Injection Control (UIC) Class VI permit for a planned facility located in McFarland, California. This plan is one of eight separate documents submitted to the U.S. EPA Geologic Sequestration Data Tool (GSDT), and includes required information regarding planned testing and monitoring activities. Numerical modeling used to define the areas of anticipated carbon dioxide migration and the Area of Review (AoR) are described in the Area of Review and Corrective Action Plan. Geologic analyses that underpin the conceptual model used in the AoR numerical modeling is primarily described in the narrative permit application report.

The permit application and associated documents were prepared by a team including Daniel B. Stephens & Associates, Inc. (DBS&A), Driltek, Finsterle Geoconsulting, Keystone Diversified Energy, Inc. (KDEI), and Best Core Services.

2. Injection Well Testing

Injection well testing activities will include carbon dioxide stream analysis, continuous monitoring of injection pressure, rate and volume, mechanical integrity testing and pressure fall-off testing.

2.1 Carbon Dioxide Stream Analysis

Anticipated injectate composition is presented in the narrative permit application report. The injectate is predicted to be 98.7-percent carbon dioxide by mass, with less than one percent of methane, benzene, ethane, and nitrogen making up the composition to 99.9-percent by mass.

The facility will have an in-house laboratory that will monitor injectate quality at least on a monthly basis, and often on a weekly or daily basis. In addition, on a quarterly basis the facility will collect a sample of the injectate for third-party laboratory analysis. Third-party samples will be extracted from a sample point just upstream of the wellhead via a valve and permitted to decompress into a gaseous phase within a sample holder for analysis by one of the methods described below. Standard methods will be used to calculate chemical and physical properties at in situ pressure and temperature from the results of analysis of the decompressed samples (U.S. EPA, 2013).

Third-party samples will be analyzed for the following using the analytical methods indicated (or equivalent with prior U.S. EPA approval):

- Carbon dioxide purity (ASTM E1747)
- Total sulfur (International Society of Beverage Technologists [ISBT] 14.0)
- Hydrogen sulfide (ISBT 14.0)
- Nitrogen (ISBT 4.0)
- Total Hydrocarbons (ISBT 10.0)
- Methane (ISBT 10.1)

All sample containers will be labeled with a unique sample identification number indicating the date of sample collection, and will be submitted under chain-of-custody protocols to an off-site third party laboratory for analysis.

Carbon dioxide injectate analyses will be submitted in semi-annual reports, including a list of all chemical analyses, original third-party laboratory reports, chain-of-custody forms, tabular results including in-house laboratory and third-party laboratory results, description of sampling activities, data interpretation, and identification of data gaps.

2.2 Injection Pressure, Rate, and Volume

Continuous recording devices will be installed to monitor injection pressure, rate, and volume. This will include:

- Gas flow control valves, backpressure and check valves to be installed on the wellhead and flow lines to ensure injection to individual completion zones.
- Temperature and pressure gauges at the surface (calibrated over the full operational range annually).

- Coriolis mass flowmeter located at the wellhead or transfer pipeline at the facility prior to the wellhead. The flowmeter will be calibrated using standard methods to within 0.1 percent over the entire expected range of flow rates.
- Surface telemetry of pressure, temperature and injection rates.
- Downhole fiber optics for monitoring of completion zone pressure and temperature by interval.
- Pressure gauge to monitor pressure on the annulus between the tubing and long-string casing to verify internal mechanical integrity.
- Downhole density calculation based on measured pressure and temperature (e.g., Ouyang, 2011).
- Volume-based flow rate will be calculated based on the mass-based flow rate and the downhole density.

Injection rate data will be submitted to the U.S. EPA in semi-annual reports. Semi-annual reports will include electronic data submission of all raw data, tabular data of all flow rate measurements, monthly average flow rate, monthly maximum and minimum values, total monthly injected volume, cumulative volume over the lifetime of the project, flagging of any flow rate exceedances, and identification of data gaps.

2.3 Corrosion Monitoring

Well corrosion monitoring will be conducted to ensure wellbore mechanical integrity over the life of the project. Corrosion will be assessed quarterly using the corrosion coupon method. Coupons representative of the long string casing, injection tubing and wellhead materials will be installed in a flow-through pipe arrangement directly upstream of the wellhead. Coupon corrosion will be evaluated based on ASTM G1-03 including photographs, dimensional measurement and weighing.

Corrosion monitoring will also include casing inspection logs using one or more of the following methods on a semi-annual basis:

- Ultrasonic imaging log to gauge casing inside and outside roughness and thickness, casing to cement bond.

- Multi-finger caliper to evaluate inner metal loss.
- Electromagnetic flux log to evaluate total metal loss.
- Downhole video if necessary to identify casing problems where other logs may be ambiguous.

Semi-annual reports will include the results of corrosion monitoring, including a narrative description of all corrosion monitoring activities, corrosion coupon measurement results in tabular form including all historical results, photographs of corrosion coupons, all casing inspection logs and interpretations, and identification of any data gaps.

2.4 External Mechanical Integrity Testing

External mechanical integrity tests (MITs) will be conducted prior to injection and annually during the injection phase of the project, and will include temperature and/or oxygen activation logs. Temperature and/or oxygen activation logs will be conducted according to U.S. EPA (2013) specifications. Temperature logs will be conducted with dedicated fiber optics for monitoring of completion zone pressure and temperature by interval by the following procedure:

- Upon well installation collect a baseline temperature profile representative of the natural geothermal gradient
- During operation record temperature profile for at least six hours prior to shutting in the well
- Stop injection and record temperature profile for approximately 36 hours.
- During the shut-in period, the temperature within the well bore will typically change toward static geothermal conditions. If there has been a leak of fluid out of the well, the temperature within the well bore at this location will change to a lesser degree and be measured as an anomaly because the temperature of the surrounding formation will have been modified by the leaking fluid (U.S. EPA, 2013).

Oxygen activation logs will be conducted only if necessary to resolve temperature logging results and further assess mechanical integrity if temperature logging results indicate potential failure.

All external MIT results will be submitted to U.S. EPA in an electronic format within 30 days of the completion of each test. MIT reports will include charts and/or tabular results of each log including a comparison of the temperature profile during injection, during the shut-in over various time periods, and the background geothermal gradient, and a description of each test including date and time of test and well shut in.

2.5 Pressure Fall-Off Testing

Upon initial completion of the injection well, a pressure fall-off test and injectivity test will be conducted to verify the fracture gradient and pressure for maximum allowable injection pressure, and a test will be repeated every five years to confirm reservoir and well conditions.

Pressure fall-off testing will include ceasing injection (shutting in the well at the wellhead) and monitoring pressure decay within the well. Continuous pressure measurements will be conducted with dedicated downhole fiber optics for monitoring of completion zone pressure and temperature by interval. A secondary pressure gauge will also be deployed during the test for verification. The shut-in period will be at least four days, or longer if needed to reach a straight-line of pressure decay on a semi-log plot.

Pressure readings and temperature within the well during the test will be plotted as a function of time prior to and during the test, including log-log and semi-log diagnostic plots. Observations of anomalous pressure decay at greater rates than previous tests may indicate a number of scenarios such as changes in relative permeability, the effects of well stimulation procedures, or leakage of fluid (U.S. EPA, 2002). The Site TOUGH numerical model will also be used to interpret the test results by adjusting model parameters to fit the observed decay curve and assess the resulting permeability.

Pressure fall-off test results will be submitted electronically to U.S. EPA within 30 days of the completion of each test in a tabular format, including a description of the test (date, duration), bottomhole pressure and temperature at specified depth(s), records of all gauges, raw data in a tabular format, injection rates and pressure prior to the test, diagnostic plots, plots of TOUGH modeling compared to pressure fall-off tests and changes to any TOUGH model parameters if necessary, calculated parameter values (permeability, transmissivity, skin factor), and identification of data gaps.

3. Groundwater Quality Monitoring

Groundwater quality monitoring will be conducted above the primary confining zone (Freeman Jewett formation) and within USDWs in the vicinity.

3.1 Above Confining-Zone Monitoring Well

One dedicated monitoring well (ACZ well) will be installed at the SJR property in the vicinity of the injection well that will be screened in the first formation overlying the confining zone that has a sufficient permeability to support collection and analysis of ground water samples (Olcese Formation Sandstone). Pressure increase within the Vedder formation is greatest at the injection well; therefore this location represents the maximum risk of vertical fluid leakage. In addition, separate-phase carbon dioxide is predicted to extend only to the direct vicinity of the project site. Figure 1 displays the planned location of the ACZ monitoring well relative to simulated carbon dioxide saturation at various times during and after injection.

The ACZ well will be screened within the Olcese Formation, which occurs from approximately 6,625 to 7,095 feet below ground surface (ft bgs) at the SJR site. Per U.S. EPA guidance the perforated interval will be in the lower parts of the Olcese, closer to the Freeman Jewett formation (perforated approximately 7,045 to 7,095 ft bgs pending verification of stratigraphy upon drilling of the injection well). The ACZ monitoring well will be drilled and constructed according to U.S. EPA (2013) specifications.

The ACZ will be fitted with a continuous pressure gauge in order to monitor increases in pressure that may indicate fluid leakage. In addition, fluid samples will be collected quarterly during the injection phase for the following per U.S. EPA (2013) protocols:

- Carbon dioxide (ASTM D513 or similar)
- Dissolved metals (EPA 200.8/200.9/7010 or similar)
- Total dissolved solids (ASTM D5907 or similar)
- Major anions (EPA 300.1 or similar)
- Major cations (EPA 6020A/6020C/700B or similar)

- pH, temperature, specific conductivity (calibrated field meter)

At least three sets of baseline water-quality samples will be collected upon installation of the ACZ monitoring well and prior to injection, spanning a period of at least six weeks. Baseline pressure will also be monitored continuously for a period of at least six weeks prior to injection.

Samples will be collected after the well has been purged sufficiently that field parameters (e.g., pH, temperature, specific conductivity) have stabilized. Samples will be collected in bottles provided by a third-party laboratory, and will be submitted under chain-of-custody protocols to the laboratory. Quality assurance/quality control (QA/QC) samples will include one field duplicate, one equipment rinsate/blank, one matrix spike (where needed based on the analytical method) and one trip blank.

3.2 USDW Monitoring Wells

Several groundwater production wells located within the AoR are routinely monitored for groundwater level and water quality as a component of compliance with the California Sustainable Groundwater Management Act (SGMA). The AoR coincides with the Southern San Joaquin Municipal Utility District (SSJMUD) Management Area, which is located within the larger Kern County groundwater subbasin (GEI, 2019). Figure 2 presents an overlay of the AoR, SSJMUD, and groundwater wells identified for monitoring under SGMA. Information regarding each of these wells is reproduced from GEI (2019) in Appendix A. Wells are owned by the City of Delano, the City of McFarland, and private parties. All supply wells in the vicinity, including these designated wells for monitoring, are screened within USDWs overlying the SJR project site. SSJMUD monitors each of these wells for water-quality data (GEI, 2019).

SJR will seek to enter into a memorandum of understanding (MOU) with SSJMUD to (1) gain access to water-quality data obtained from each of the monitoring wells in their network within the AoR; and (2) if needed in order to obtain necessary water-quality parameters, obtain access to the wells for periodic direct sampling. SSJMUD wells within the project AoR include Delano Well 14, McFarland Taylor Well, SSJMUD-23, SSJMUD-42, SSJMUD-53 and SSJMUD-14.

SJR will seek to collect the following data on a semi-annual basis:

- Carbon dioxide (ASTM D513 or similar)
- Dissolved metals (EPA 200.8/200.9/7010 or similar)

- Total dissolved solids (ASTM D5907 or similar)
- Major anions (EPA 300.1 or similar)
- Major cations (EPA 6020A/6020C/700B or similar)
- pH, temperature, specific conductivity (calibrated field meter)

All data, including original laboratory reports and field notes, will be obtained from SSJMUD if possible. If SJR needs to collect samples independently, samples will be collected after the well has been purged sufficiently that field parameters (e.g., pH, temperature, specific conductivity) have stabilized. Samples will be collected in bottles provided by a third-party laboratory, and will be submitted under chain-of-custody protocols to the laboratory. Quality assurance/quality control (QA/QC) samples will include one field duplicate, one equipment rinsate/blank, one matrix spike (where needed based on the analytical method) and one trip blank.

3.3 Data Interpretation and Reporting

SJR will maintain an electronic database of all monitoring results, that will record date of sample collection, resulting sample concentrations, analysis date, analytical detection limit, and any QA/QC flags.

All groundwater quality data will be subjected to standard quality review prior to data interpretation per Standard Methods (1999). Data quality evaluation will include calculation of the cation-anion balance (CAB) with the following acceptable criteria:

- Anion Sum (meq/L) 0 – 3.0, Acceptable Difference = 0.2 meq/L
- Anion Sum (meq/L) 3.0 – 10.0, Acceptable Difference = 2%
- Anion Sum (meq/L) 10 – 800, Acceptable Difference = 5%

Charge balance error will also be calculated for analyses where the anion sum is greater than 800 meq/L, with the limit of accepting an analysis by the charge balance error calculation being 5%. A final check will include comparison of measured and calculated TDS, and the ratio of measured to calculated TDS should be within 1.0 to 1.2 (Standard Methods, 1999).

SJR will evaluate all groundwater quality monitoring data against baseline samples collected prior to injection for any indication of fluid leakage, including:

- Increasing TDS
- Changing major cation/anion signature, as displayed on standard Piper and Stiff diagrams
- Increasing carbon dioxide concentration
- Decreasing pH
- Increasing concentration of dissolved metals, which (along with other indications listed above), may indicate leaching of certain inorganics from the formation due to lowered pH

Groundwater quality monitoring results will be reported to U.S. EPA in semi-annual reports and in an electronic format, including the most recent water-quality database including all recent and historical results, complete original laboratory reports, data interpretation including time series charts, Piper and Stiff diagrams, narrative explanation of all sampling activities, data quality evaluation, calibration records for field meters, and identification of data gaps.

4. Plume and Pressure Front Tracking

As required by the Class VI rule, plume and pressure-front tracking within the Vedder formation will include the following:

- Direct pressure monitoring within the injection well and a monitoring well that will be installed within the Vedder formation
- Indirect geophysical monitoring (surface seismic) on a repeated basis within the area of projected carbon dioxide migration
- Computational modeling that is updated to incorporate monitoring results (computational modeling methodology is discussed in the AoR and Corrective Action Plan).

Pressure will be monitored directly within the injection well as discussed in Section 2, above. In addition, a monitoring well will be installed updip of the project in order to track pressure increases in the vicinity and ensure that pressure increase is similar to model projections. Figure 2 displays the planned location of the Injection-Zone (IZ) monitoring well (35.692503, -

119.242309). The IZ monitoring well will be perforated exclusively within the Vedder formation, which is approximately 6,672 ft bgs at this location. Final perforated interval will be determined based on updated stratigraphy obtained during monitoring well drilling. The IZ monitoring well will be fitted with a downhole transducer for continuous pressure measurement.

Figure 3 presents the simulated pressure changes at the IZ monitoring well location during the lifetime of the project based on the project TOUGH numerical model. Pressure measurements at the IZ well and injection well will be compared to corresponding model-simulated pressure profiles to confirm that pressure increases within the Vedder formation are not greater than simulated. Pressure monitoring data will be submitted to U.S. EPA in semi-annual reports, including raw pressure data, transducer calibration logs, time-series graphs of measured pressure versus model-simulated predictions, and identification of data gaps.

Indirect plume monitoring will include time-lapse three-dimensional surface seismic surveys covering the entire extent of the area anticipated to be subject to carbon dioxide migration. Figure 2 displays the anticipated seismic area overlaid with model simulated extent of carbon dioxide during the lifetime of the project. The anticipated area for seismic surveys is approximately six square miles. The 3D seismic survey will be conducted prior to injection (baseline), and at years 2, 5 and 10 during the injection phase. Seismic methods will be consistent with U.S. EPA (2013) including ensuring that the exact same methodology is used in repeat surveys.

Surface-seismic results will provide an indication of whether supercritical-phase carbon dioxide is present in any given location, but does not generally provide an estimate of carbon dioxide saturation. Plan-view maps of survey results will be compared to model-predicted carbon dioxide extent as shown in Figure 2. Geophysical survey results will be submitted to U.S. EPA in semi-annual reports following the survey event, including a detailed independent report by the geophysical contractor of all survey methods, map(s) showing all survey equipment positions, date/time of all survey data collection, near surface conditions during the test, raw seismic data and interpreted diagrams, maps showing the location of the carbon dioxide plume, and maps comparing the carbon dioxide plume progression over time to model simulated projections. All geophysical surveys and reporting will be overseen by a California Registered Professional Geophysicist.

References

GEI Consultants (GEI), 2019. Southern San Joaquin Municipal Utility District Management Area Plan. Submitted to Southern San Joaquin Municipal. December 2019.

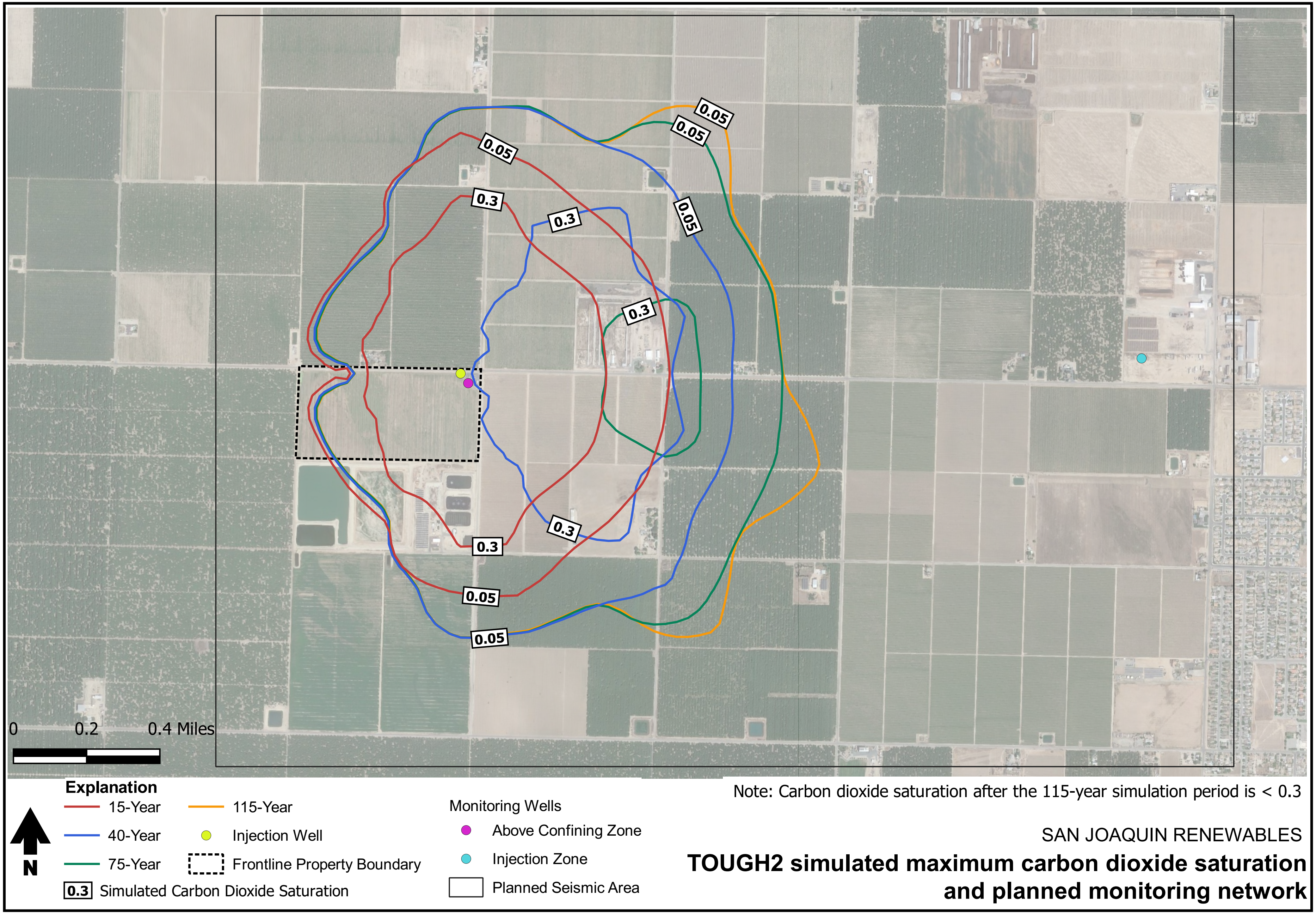
Ouyang, 2011. New Correlations for Predicting the Density and Viscosity of Supercritical Carbon Dioxide Under Conditions Expected in Carbon Capture and Sequestration Operations. The Open Petroleum Engineering Journal, 2011, 4, 13-21.

Standard Methods for the Examination of Water and Wastewater (Standard Methods), 1999. Section 1030 E Checking Correctness of Analyses. Prepared and published jointly by American Public Health Association, American Water Works Association, and Water Environment Federation, 20th Edition.

United States Environmental Protection Agency (U.S. EPA), 2002. EPA Region 6 UIC Pressure Falloff Testing Guideline, Third Revision (August 8, 2002).

United States Environmental Protection Agency (U.S. EPA), 2013. Underground Injection Control (UIC) Program Class Six Well Testing and Monitoring Guidance. Office of Water (4606M) EPA 816-R-13-001, March 2013.

Figures

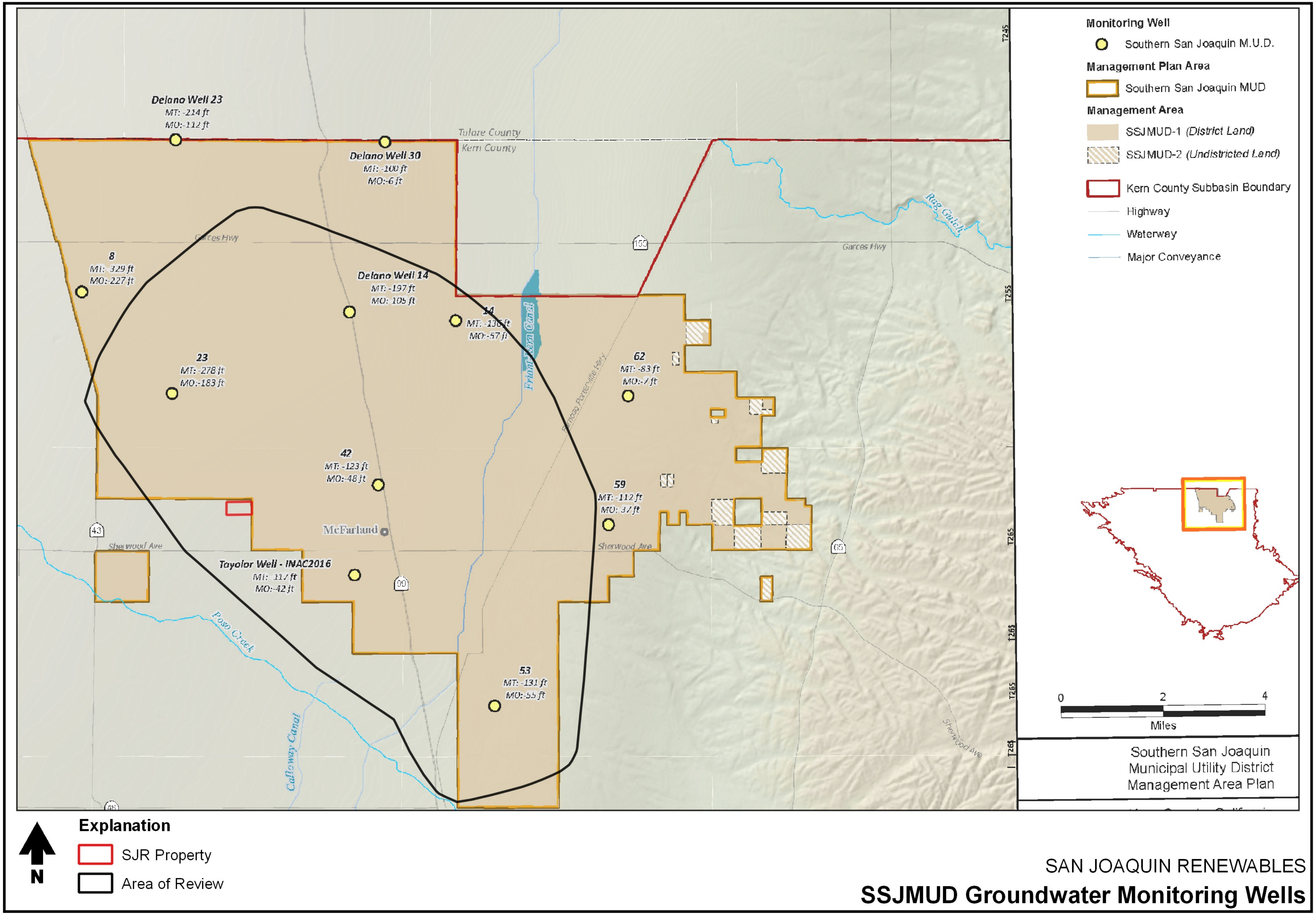


SAN JOAQUIN RENEWABLES

TOUGH2 simulated maximum carbon dioxide saturation and planned monitoring network

09/14/2021 JN DB19.1252

Figure 1



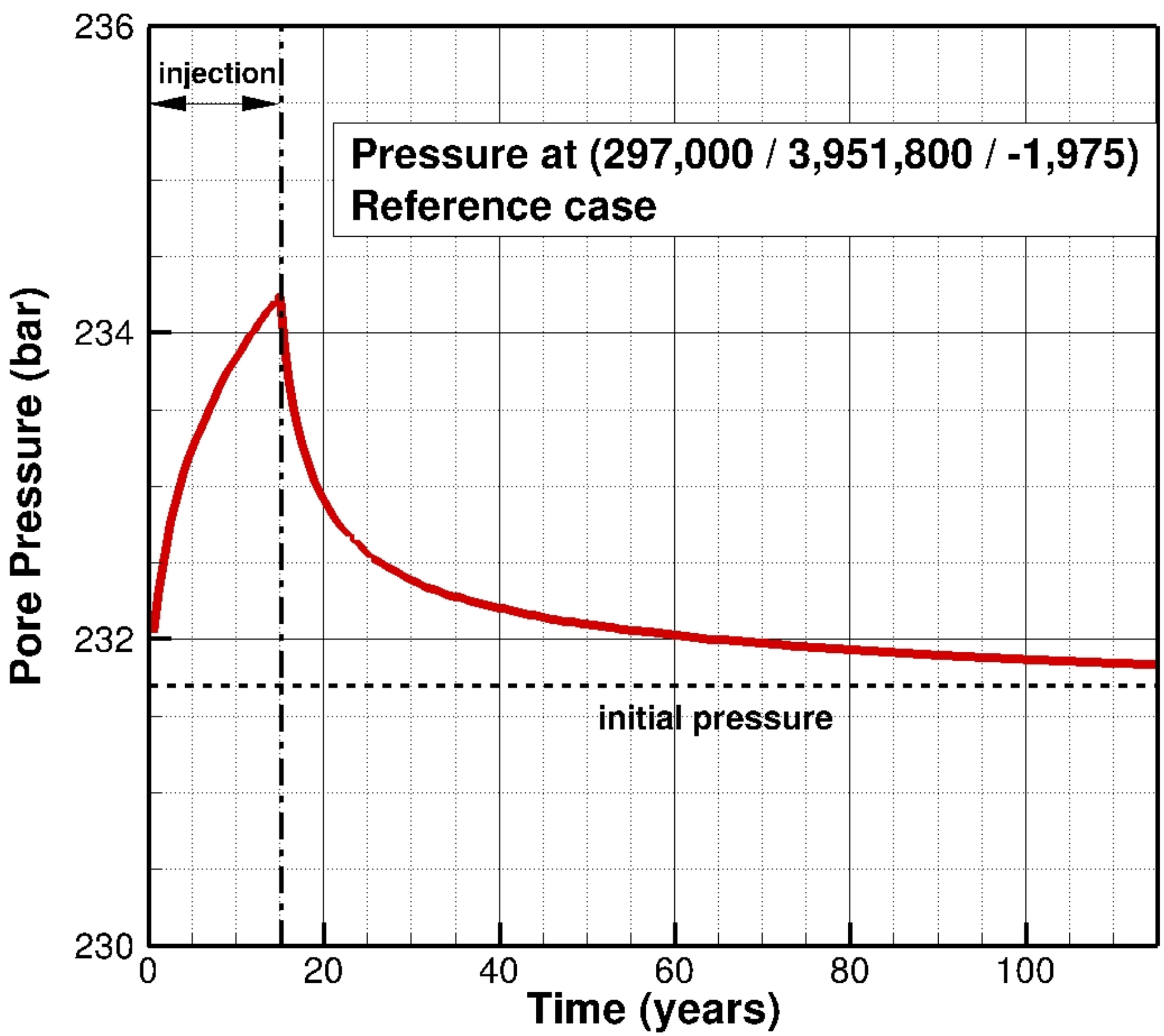
C:\Users\1179\Desktop\Frontline\Spatial Dist of the water monitoring sites.qgz

SAN JOAQUIN RENEWABLES

SSJMUD Groundwater Monitoring Wells

10/04/2021 JN DB19.1252

Figure 2



SAN JOAQUIN RENEWABLES

Simulated Pressure Profile at Pressure-Front Tracking Well Location, Vedder Formation

Appendix A: SSJMUD Groundwater Monitoring Wells Locations

Table 4-3. SSJMUD Water Level and Water Quality Monitoring Network

Well No.	DMS ID	T-R-S	Latitude	Longitude	GSE (ft MSL)	RP Elev. (ft MSL)	Coord Source	Monitoring Type	Owner	Management Area Plan Well Monitoring Status	To be replaced	Management Area Plan Parameters Type	Year Constructed	Borehole Depth (ft)	Well Depth (ft)	Perforated Interval (ft)	Annular Seal (ft)	Casing Diameter (in)	Aquifer Zone
Delano Well 14	--	25S-25E-23H	35.742	-119.242	308		City of Delano	Supply Well	Municipal	Interim	Yes	WL and WQ	--	--	--	--	--	--	Main Production
Delano Well 23	--	25S-25E-05C	35.790	-119.303	264		City of Delano	Supply Well	Municipal	Interim	Yes	WL and WQ	--	--	--	--	--	--	Main Production
Delano Well 30	--	25S-25E-01B	35.790	-119.231	338		City of Delano	Supply Well	Municipal	Interim	Yes	WL and WQ	--	--	--	--	--	--	Main Production
McFarland Taylor Ave. Well	--	26S-25E-13E	35.667	-119.240	359		City of McFarland	Supply Well	Municipal	Interim	Yes	WL and WQ	--	--	--	--	--	--	Main Production
SSJMUD Well 8	--	25S-24E-13P2	35.74702	-119.336	265	259	District	Supply Well	Private	Interim	Yes	WL and WQ	--	--	--	--	--	--	Main Production
SSJMUD Well 14	--	25S-26E-19J1	35.73948	-119.205	354	351	District	Supply Well	Private	Interim	Yes	WL and WQ	--	--	--	--	--	--	Main Production
SSJMUD Well 23	--	25S-25E-29R2	35.7185	-119.304	294	292	District	Supply Well	Private	Interim	Yes	WL and WQ	--	--	--	--	--	--	Main Production
SSJMUD Well 42	--	25S-26E-01P2	35.69295	-119.232	342	338	District	Supply Well	Private	Interim	Yes	WL and WQ	--	--	--	--	--	--	Main Production
SSJMUD Well 53	--	26S-26E-32	35.63068	-119.191	433	430	District	Supply Well	Private	Interim	Yes	WL and WQ	--	--	--	--	--	--	Main Production
SSJMUD Well 59	--	26S-26E-10	35.682	-119.152	513	512	District	Supply Well	Private	Interim	Yes	WL and WQ	--	--	--	--	--	--	Main Production
SSJMUD Well 62	--	25S-26E-26	35.71837	-119.145	474	472	District	Supply Well	Private	Interim	Yes	WL and WQ	--	--	--	--	--	--	Main Production